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Interferometric and Optical Tests of Water Window Imaging X-ray Microscopes

FINAL REPORT

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Interferometric and Optical Tests of Water Window Imaging X-ray Microscopes

The Center for Applied Optics of the University of Alabama in Huntsville is pleased to submit this final report entitled "Interferometric and Optical Tests of Water Window Imaging X-ray Microscopes" that documents the activities and results for NASA P.O No. H-13030D.

Under previous efforts, NASA/MSFC has fabricated normal-incidence multilayer optical systems for the Water Window Imaging X-ray Microscope program. Under another contract, the preliminary alignment of two Schwarzschild X-ray microscope systems was accomplished using the Center for Applied Optics' Zygo interferometer. To support the objectives of this instant program, advanced aspheric microscopes were fabricated, but not assembled nor aligned. As part of NASA P.O. No. H-13030D, these new microscope systems were assembled and tested using interferometric methods similar to those applied to the aforementioned Schwarzschild optical systems.

During the initial period of this contract, UAH personnel used the CAO's Zygo interferometer to perform interferometric tests on the Schwarzschild X-ray microscope to evaluate the focal properties and optical alignment of the consistent components. The testing was performed in the optics laboratory of NASA/MSFC/SSL. Results of the investigation indicated that the optical performance was nominally what was expected except that the coatings were observed to have less than adequate performance.

Another task under this contract involved performing resolution tests, by using resolution test targets and ultrahigh resolution photographic films, to gain an understanding of the optical characteristics of the aforementioned microscopes as a function of field angle and focal position. The objective was to quantify the properties of field curvature, optical vignetting effects, and off-axis behavior. In order to accomplish this objective, UAH personnel began photographic tests using facilities located at MSFC in the X-ray Optics Laboratory of SSL. In particular, UAH personnel assisted in the

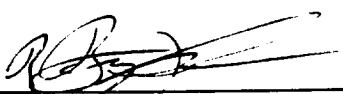
installation and check-out of automated photographic film and paper processing equipment since this equipment was needed to perform proper testing of the Water Window Microscope.

After installation of aforementioned processing equipment, UAH personnel began developing expertise in utilizing the automated processing and testing equipment for photographic materials to be used with the Water Window Microscope. Due to the complex nature of the processing equipment, UAH personnel developed an appropriate preventive maintenance schedule and began following said schedule. Implementation of the maintenance schedule should save the Government significant repair and replacement costs. Appendix A presents the Paper Processing Maintenance Schedule.

UAH personnel developed procedures for using the acquired processing equipment and verified these procedures to enhance existing MSSTA flight images that were previously unusable due to improper exposure during the flight. Experience was gained by working with the same types of 70-mm films that will be used to capture images formed by the Water Window Microscope. Due to the difficulty and cost of obtaining time on the X-ray source, it is important that exposure and processing procedures be established for films prior to their use with the Water Window X-ray microscope.

During the later period of this contract, UAH personnel continued refining and enhancing procedures and techniques for utilizing the automated processing equipment. The overall improvement was verified by observation of the significant increase in the degree of enhancement obtained in processing the existing MSSTA flight images. Based upon the knowledge gained from the enhancement of the MSSTA flight images, film was prepared for testing at the NIST synchrotron (X-ray source). After exposing these film at the synchrotron, a variety of experiments were conducted to determine the specific procedures that will produce the best images, especially for those cases when the film is underexposed. These techniques may also be useful for processing the next MSSTA flight film should the film be improperly exposed.

Additional procedures for using the automatic film processing equipment were developed. A series of experiments were conducted to determine the processing characteristics of several photographic developers. The objective of these experiments was to determine the performance response of the flight films when "push" processing methods were employed, i.e., how much the contrast increases and the resolution decreases. The objectives of this effort were achieved and NASA's ability to more optimally process film that will be exposed using the Water Window X-ray Microscope has been enhanced.



R. Barry Johnson
Principal Investigator

21 July 1993

Date

APPENDIX A.

PAPER PROCESSOR MAINTENANCE SCHEDULE.

In order for the paper processor to produce optimum results, periodic maintenance is necessary. This unit consists of a complex assortment of rollers, gears and other moving parts. Combine this machine with photographic chemicals which tend to form deposits as evaporation occurs, and the stage is set for problems. Compounding this problem is the fact that the water supply is blessed with an exceptional amount of calcium. The end of result of mixing photochemicals with a calcium-laden water supply is an abundance of deposits of various salts. This maintenance schedule was developed to keep the intricate machinery operational.

DAILY (EXCEPT FRIDAYS)

At the end of each day of processing paper, the cover of the unit should be removed and left off overnight to prevent condensation with the machinery. The cover should be replaced on the following morning. If the unit was not used during a given day, then the cover should remain on.

FRIDAYS

At the end of each week, the photochemicals should be drained from the reservoir and stored in the 5 gallon carboys located in the SSL darkroom. After removal of the solutions, both reservoir should be flushed with tap water. Both roller/cog assemblies should be removed and scrubbed in the plastic bin that can with the unit for this very purpose. The use of a mild detergent with warm water and a scrubber-sponge will remove all but the most stubborn spots. For these spots, a soak in warm soapy water for 30 minutes followed by scrubbing with a mild abrasive (such as Soft Scrub™) will provide most satisfactory results.

BI-WEEKLY

Every two weeks, under daily user of the processor, the photochemicals will become depleted. Under heavy use of the processor, depletion will occur sooner. However, note that even without use, the chemicals will still undergo oxidation and thereby become unusable. At this point, the chemicals need to be drained from both reservoir and disposed of. The tanks need to be flushed with tap water and the filtering screens need to be cleaned. Fresh chemicals can then be mixed and added to the processor.

STORAGE DURING PERIODS OF NON-USE

During extended periods of non-use, the chemicals in the tanks need to be removed and the roller/gear assemblies cleaned. The tanks should then be filled to capacity with tap water, then the cover should be replaced. When the processor is in this condition — tanks full of water, not photochemicals — it is recommended that a note be affixed to the processor so that someone attempting to use the unit will be aware of the fact that there are no chemicals in the tanks.



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